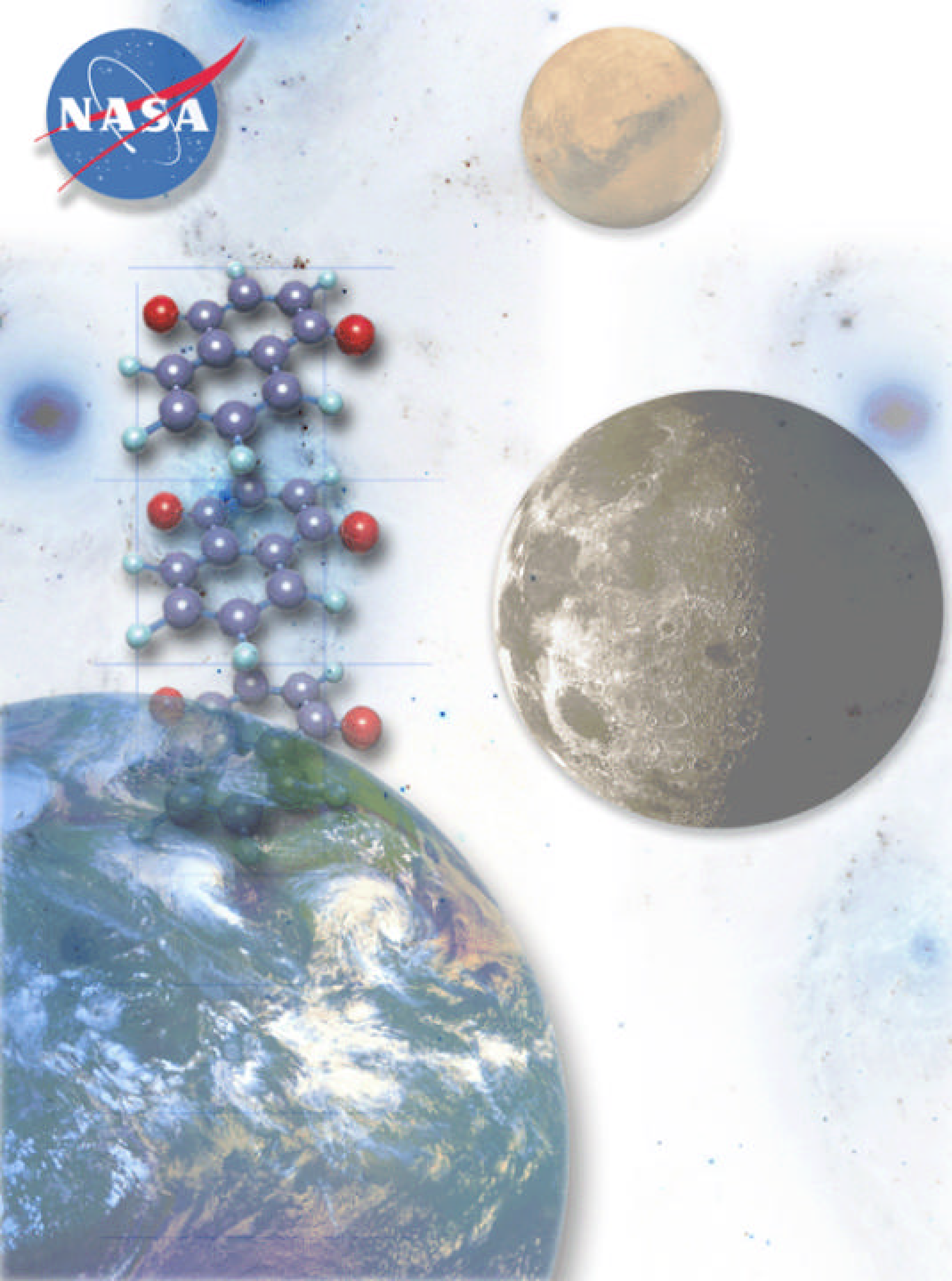

NASA Exploration Team

FY02 Annual Report

National Aeronautics and Space Administration

NASA Exploration Team (NEXT)

The NASA Administrator charged the NASA Associate Administrators for Space Science and Space Flight to establish the Decadal Planning Team (DPT) in June 1999 and chartered it to apply a systems engineering approach to develop the investment strategies and plans needed to enable integrated robotic/human space exploration activities during the first quarter century of the millennium.

In August, 2002, a Memorandum of Agreement between the NASA Offices of Space Science, Biological and Physical Research, and Space Flight established a structure and process known as the NASA Exploration Team (NEXT) to coordinate activities to create and enable a multi-Enterprise, long-term vision for human/robotic exploration of space.

NEXT is an interdisciplinary, multi-Enterprise, cross-Center team responsible for maintaining a multidisciplinary approach toward future exploration planning. NEXT has primary responsibility for cooperatively providing the options, priorities, and assessments for future human and robotic exploration to achieve NASA's mission of "To explore the universe and search for life." In addition, NEXT coordinates current technology investments, advocates new initiatives, and ensures alignment of long range strategic planning to achieve this goal.

The NEXT consensus is that an integrated, sustained technology breakthrough investment program, linked to specific capability goals that are traceable to major, NASA-wide scientific objectives, is pivotal. While the NEXT strategy is science-driven, it is technologically enabled on the basis of derived requirements associated with specific incremental capabilities. Exploration hurdles must be overcome in areas including space transportation, power, crew health and safety, human-robotic operations, and space systems performance.

A near-term, leveraged technology investment and development program is required to execute the incremental approach and enable the decision space and pathways to achieving human permanence in deep space. The NEXT strategy requires careful attention to gaps in technologies as well as integrating a wide range of ongoing technology investments using NEXT-identified requirements. The NEXT process to develop a technology portfolio and road maps is an annual Agency-wide and interagency approach.

NASA Exploration Team (NEXT)

- Chartered in June 1999 as the *Decadal Planning Team* to create an integrated strategy for science-driven, technology-enabled space exploration…not destination-driven
- Memorandum of Agreement (MOA) between Codes S, U, and M signed in August 2002
- Coordinates a team across the entire Agency: a badgeless "virtual Center" with senior participants from all Centers
- Focuses on revolutionary – not evolutionary – approaches: pushing the boundaries to enable what was not possible before
- Develops alternative scenarios, architectures, and mission concepts to achieve NASA science goals with >10-year horizon
- Initiates technology road maps, investment priorities, and new initiatives:
  - In-Space Propulsion Technologies program *(FY02 Initiative – funded)*
  - Nuclear Systems Initiative *(FY03 Initiative)*
  - Radiation Research Initiative *(FY03 Initiative)*
- In FY03 and beyond, NEXT is evolving under the leadership of the Agency's new Space Architect as cross-Enterprise, cross-Center working groups to participate in the development and implementation of NASA's integrated space strategy

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FY02 Highlights

- *Overview*
- Architecture Concepts
- Exploration Hurdles
  - Space Transportation
  - Power
  - Crew Health and Safety
  - Human and Robotic Operations
  - Space Systems
- Technology Planning
- Leveraging and Partnering
- Future Direction

Overview –
Memorandum of Agreement Establishing the NASA Exploration Team

Human and robotic exploration planning in NEXT draws from three NASA Enterprises: space science requirements from the Office of Space Science; crew health, research, and countermeasures from the Office of Biological and Physical Research; and human space flight interests from the Office of Space Flight.

Accordingly, the Associate Administrators of the these Enterprises agreed that it is in the best interest of their organizations to formalize the coordination in developing the strategy, options, and priorities for human/robotic exploration of space.

This Memorandum of Agreement establishes a structure and process to be known as the NASA Exploration Team (NEXT) which will coordinate activities – as described in the charter – to create and enable a multi-Enterprise long-term vision for human/robotic exploration of space.

To achieve NASA's mission of "To explore the universe and search for life," the Enterprises, through this Memorandum of Agreement, established a single entity that has responsibility for cooperatively providing the options, priorities, and assessments for future human/robotic exploration. In addition, NEXT coordinates current technology investments, advocates new initiatives and ensures alignment of long range strategic planning to achieve this goal.

With respect to this activity, the Enterprises reserve to themselves the determination of science priorities; management of missions, projects, programs; and the budgets to carry them out.

Memorandum of Agreement Establishing the NASA Exploration Team

Purpose/Scope

Establishes a single entity that has the responsibility to coordinate activities to create and enable a multi-Enterprise long-term vision for human/robotic exploration of space which achieves NASA's mission "To explore the universe and search for life."

Responsibility

1) Promote alignment of Enterprise strategic plans.
2) Collect scientific requirements and generate technical and programmatic requirements to assess strategic technology investments and ongoing NASA programs within the scope of the Memorandum of Agreement.
3) Conduct and coordinate advanced concepts analyses and develop new innovative approaches for space exploration.
4) Assess technology programs and pursue alignment of relevant programs with the NASA exploration vision and missions.
5) Identify and promote commercial and space development opportunities that are consistent with the vision.
6) Identify resources and requirements that could be added to an existing activity to yield benefits for more strategic purposes.
7) Serve as the source of studies for incubating the Agency's space exploration technology efforts and decision tools.
8) Manage a small investment portfolio for specific concepts and technologies that would serve as seed money for future initiatives.

Overview –
NASA's Vision & Mission

NASA's mission is research-driven and will be carried out to pursue the study of the origins of the universe and the evolution of galaxies, stars, and planets; to determine how the Sun and Earth are changing and predict future changes; and to seek evidence of life on planets and moons in our Solar System and on planets around distant stars.

Understanding and protecting our home planet includes activities to help our country address national needs related to the safety and security of our air transportation system, to understanding global climate change, and to rapidly transfer technologies to others.

Exploring the Universe and the search for life will be based on decisions that are science-driven and not destination driven. This will be enabled by technology, first with robotic trailblazers, and eventually humans. Human presence beyond low-Earth orbit will be enabled as a means to scientific exploration. Investments will be justified by their contribution to the long-range vision.

Education is part of the NASA mission and will be an integral part of programs. Students will be motivated to pursue careers in science, math, and engineering. Educators will be provided with unique teaching tools and compelling teaching experiences. The public will be engaged in shaping and sharing the experience of exploration and discovery. NASA will pursue activities unique to our mission in air and space: if NASA did not do these unique activities, they would not be accomplished. These activities will be integrated across the Agency.


www.nasa.gov
The NASA Vision
To improve life here,
To extend life to there,
To find life beyond.
The NASA Mission
To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.

Overview –
To Explore the Universe and Search for Life

The NEXT strategy incorporates all of NASA’s strategic scientific priorities as defined in the Agency and Enterprise strategic plans. These priorities may be summarized in the context of fundamental scientific questions:

How did we get here? This question covers the Big Bang; the origin of the Universe; and the origin of galaxies, stars, planets, and life from the origin of life on the Earth through its evolution to the human species.

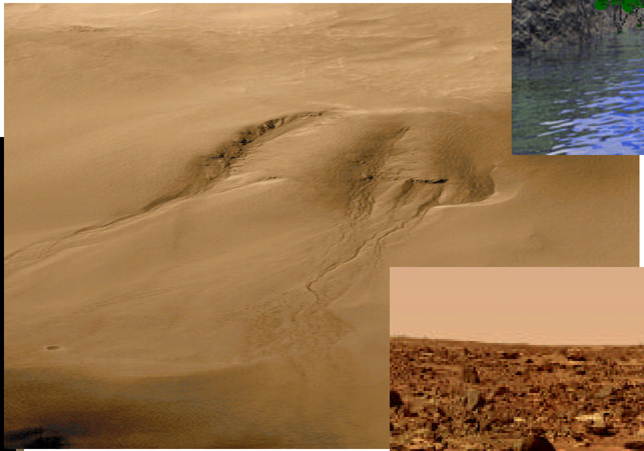
Where are we going? What will happen to our own planet and to the Universe itself? The changing nature of the Universe was demonstrated for the public in our own cosmic backyard by the collision of comet Shoemaker-Levy with Jupiter. We will seek answers to this question by reading the destiny of the Solar System. What is its fate and what does its evolution imply for other planetary systems?

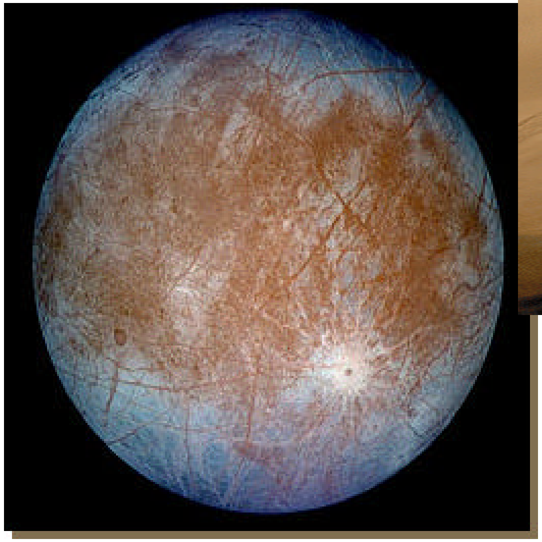
Are we alone? This is the most profound question of all. Does life exist beyond Earth? Did life exist on Mars or elsewhere in our Solar System? Do civilizations exist on planets around other stars?

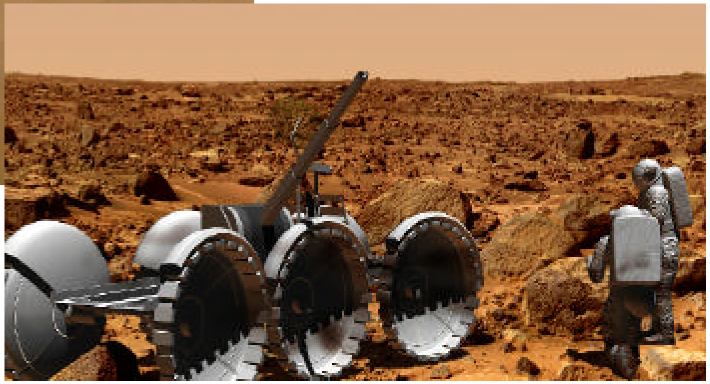
The purpose of these scientific questions is to articulate the motivation and core justification for space exploration in a manner that is both credible to professionals and captures the interest of the American public.

To Explore the Universe and Search for Life

- Exploring the Universe and the life within it… enabled by technology, first with robotic trailblazers, and eventually humans… as driven by these compelling scientific questions:
  - How did we get here?
  - Where are we going?
  - Are we alone?







Overview –
Are We Alone? – Objectives, Science Approach, and Priority Questions

Understanding the traceability from the fundamental science questions is critical to implementing the NEXT strategy. The fundamental science questions are a derived set of exploration objectives and priority science questions to be answered to achieve the objectives.

As an example of science traceability, one of several objectives that addresses the fundamental science question, “Are We Alone?,” is the search for life elsewhere in the Universe. A principal activity in the search for life in the Universe is the detection and imaging of planets with hospitable environments.

Detecting and imaging planets with potentially hospitable environments requires us to understand the signposts of habitability and life. These include an atmosphere (carbon dioxide); a warm, wet atmosphere (water); and an atmosphere out of chemical equilibrium (since the global presence of life can modify an atmosphere producing trace compounds).

These specific science criteria provide the framework to begin the design of systems and facilities, initiate technology investment and development activities, and begin mission and architecture studies to support our pursuit.

Are We Alone? – Objectives, Science Approach, and Priority Questions

Exploration Objectives	Science Approach and Priority Questions
Reveal the cycles of life in the Universe	Understand the universal principles and processes that are necessary for life. • How is organic material produced in the cosmos and what forms does it take? • What are the fundamental characteristics of life (e.g., origins and early evolution, frequency, use of energy and nutrients, impact on environment, etc.)? • What is the range of terrestrial, planetary, and cosmic environments that provide the necessary conditions for life, and under what conditions can life flourish? • What is the distribution of organic and biogenic material and how is it incorporated into planets?
Search for life in the Solar System	Search for life on Mars and in promising worlds in the outer Solar System. • Did life ever arise on Mars or elsewhere in the Solar System? • Do other locations in the Solar System harbor the potential for life?
Search for life in the Universe	Determine the frequency and location of life in the Universe, and the relationships between stars and planets under which life can originate. • What are the fundamental processes of planetary and stellar formation and evolution? • How common are planets like the Earth? • What are the fundamental characteristics of stars and planetary systems that affect the habitability of their environment? • Does life exist elsewhere in the Universe? • Does intelligent life exist elsewhere in the Universe?

Overview –
Science Drivers Determine Destinations (Selected Examples)

Following the traceability and flowdown of the fundamental science questions to the science approach and priority questions, NEXT has defined specific pursuits to be undertaken to address the science questions and to focus the science discovery process.

Activities include experiments, protocols, and measurements needed to address the fundamental science questions. Identification of exploration destination options follows. Program and mission opportunities for humans and robots will then be defined and technology development activities and mission studies will commence.

The NEXT Stepping Stone strategy establishes how these destinations will be pursued. Each step of the exploration strategy will be chosen to be highly leveraged among potential exploration paths to build a capability with inherent flexibility for the future. Each capability builds on a previous step allowing NASA to leverage development of critical systems and create flexibility for the future.

Science Drivers Determine Destinations (Selected Examples)

Vision and Mission	Science Questions	Pursuits	Activities	Destinations
	• How did the Solar System evolve?	• History of major Solar System events	• Planetary sample analysis: absolute age determination “Calibrating the Clocks”	• Asteroids • Mars • Moon • Venus
	• How do humans adapt to space?	• Effects of deep space on cells	• Measurement of genomic responses to radiation	• Beyond Van Allen Belts
	• What is Earth’s sustainability and habitability?	• Impact of human and natural events upon Earth	• Measurement of Earth’s vital signs “Taking the Pulse”	• Earth Orbits • Libration Points
	• Is there Life beyond Earth?	• Origin of life in the Solar System • Origin of life in the Universe	• Detection of bio-markers and hospitable environments	• Cometary Nuclei • Europa • Libration Points • Mars • Titan

Overview –
Stepping Stones Exploration Strategy

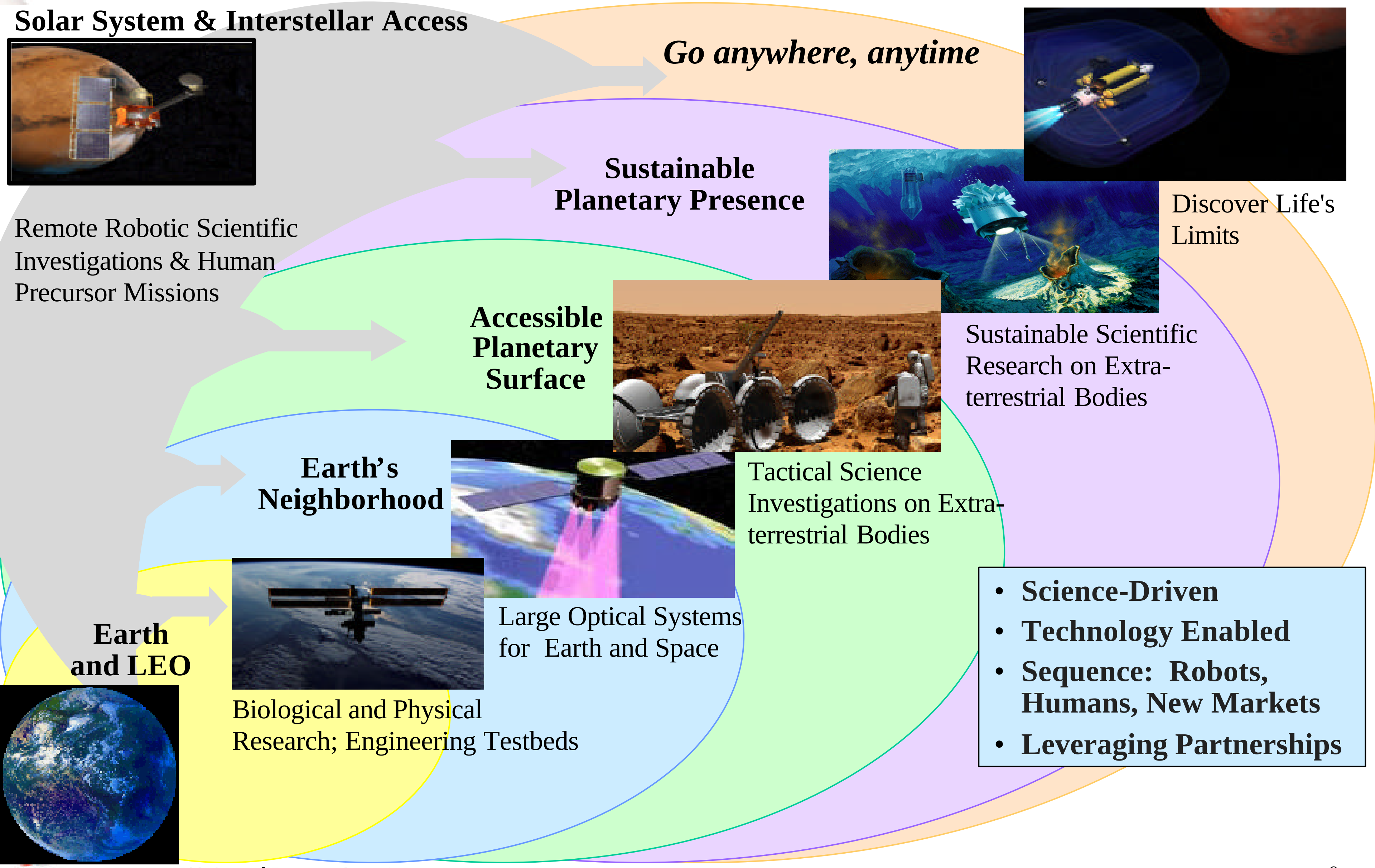
The NEXT strategy is revolutionary and requires humans and robots to work together. While the strategy is scientifically driven, it is technologically enabled. With the stepping stone approach, NASA will build the technical capabilities needed for each step in its journey to deep space. Each step will be highly leveraged among potential exploration paths to build a capability with inherent flexibility for the future. Since each capability builds on a previous step, NASA leverages development of critical systems and creates flexibility for the future.

This approach begins with outposts or observatories in the Earth's Neighborhood – defined as Earth-Moon libration points, Sun-Earth libration points, and the Moon itself – and progresses to accessible planetary surfaces, such as Mars, and outer planets as experience warrants and as technology readiness and funding permit. The approach capitalizes on progressive exploration capabilities, where the experience and infrastructure gained from each new architecture enables travel to new destinations.

After traveling to more distant libration points and possibly living on the Moon, the next likely target is Mars. By this time, robotic precursor missions to Mars will have fully characterized the surface environment and identified the primary science targets.

The outer planets will almost certainly be the exclusive realm of robotic exploration for the near term. This is the realm not just of the giant planets themselves, but of a large number of diverse satellites and free small bodies. Among the most interesting are Europa, with its potential for a subsurface ocean; Titan, which may have hydrocarbon fluids and organic snows on its surface; and cometary objects, which may contain the most primitive Solar System material including prebiotic organic compounds.

Stepping Stones Exploration Strategy



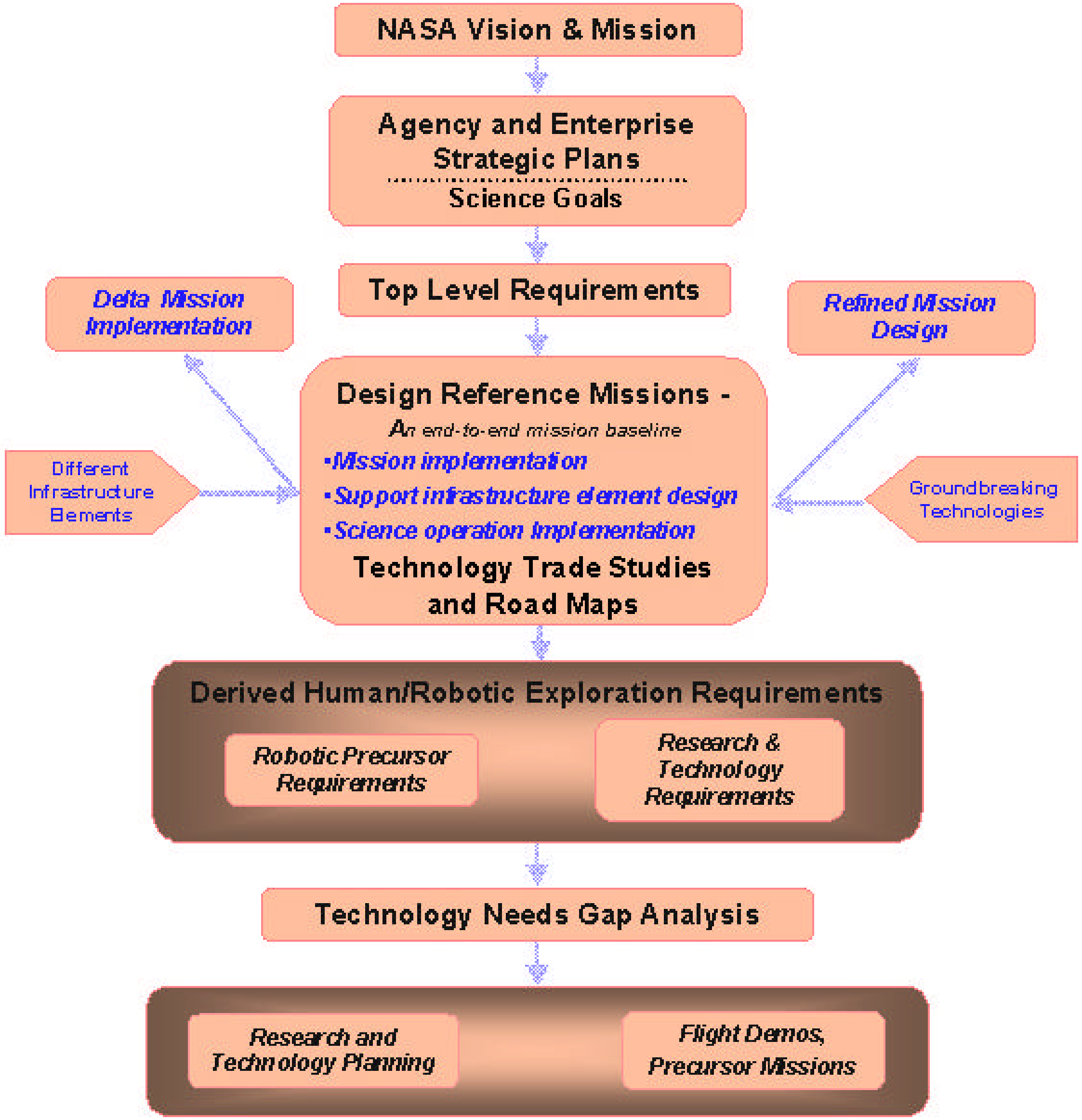
Overview –
Derived Human/Robotic Exploration Requirements

The Agency and Enterprise Strategic Plans identify near-term priorities and longer-term investments that accomplish the NASA Vision and Mission. Science goals for the Agency are articulated within these strategic plans. Advisory groups including the National Academy of Sciences and the National Research Council provide recommendations for these science goals. NEXT has developed a set of top level requirements to accomplish space exploration relevant to NASA's strategic plans that address fundamental science questions.

From these top level requirements and science goals, a series of design reference missions are developed to understand the required architecture elements and the associated technologies. Infrastructure elements and groundbreaking technologies are iterated to refine the design reference missions and to better understand alternate implementation options. Analyses of the interrelated technology requirements inherent in the architectures and mission options leads to specific technology trade studies and technology road maps to define the technology performance and mission precursor requirements necessary to execute the space exploration strategy.

Gap analysis of the road maps against current capabilities and known technology development efforts results in identification of the highest priorities for technology development providing recommendations for new initiatives. Requirements recommendations for ongoing NASA development programs including flight demonstrations for qualifying technologies and precursor missions data needs are also articulated.

Derived Human/Robotic Exploration Requirements



Overview –
Enabling the Strategy

Accomplishing the stepping stone strategy safely and affordably requires technical capabilities beyond those currently available. These enabling technical requirements or exploration "hurdles" have been defined in the following areas: space transportation, power, crew health and safety, human and robotic operations, and space systems.

We must achieve advances in space transportation technology. Technical gains must improve the safety and reliability levels of space transportation systems – both Earth-to-orbit and in-space – while making significant improvements in efficiency (affordability), capacity (to move greater mass), and speed.

Our ability to generate and store energy must be improved to meet the power demands of longer exploration missions while mitigating the concomitant increases in associated mass.

We must increase our knowledge of the space-related risks to human exploration crew members. Technology improvements must be made to mitigate or eliminate those risks. At the same time, as crew members conduct operations in environments inimical to humans and beyond the support of Earth-bound medical care, we must advance our ability to monitor and maintain crew health. Advances are required in remote or automated prophylaxis, diagnostics, and treatment related to disease and injury.

The use of human and robotic partnerships adds significantly to our capabilities in exploration. Technology improvements in robot physical capability, sensor capability, operational autonomy, data processing, and communications will improve overall exploration efficiency, economy, and risk mitigation and will enable exploration operations in venues not open to direct human presence.

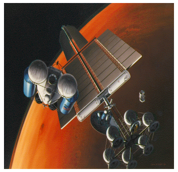
We must achieve improvements in systems design, fabrication, and performance. Increased materials and systems strength-to-weight and performance-to-weight, simplified assembly and self-assembling structures and systems, autonomous system repair, and automated (self-sufficient) systems that carry out needed operations including the use of in situ resources will all contribute to the achievement of our exploration goals.

Technical achievements in each hurdle area are not independent. Each will play a hand in the complex trade-offs between requirements, performance capabilities, costs, and risks.

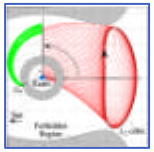
Enabling the Strategy

The Exploration Hurdles

- **Space Transportation**
  - Improve safety, cost effectiveness, and efficiency
- **Power**
  - Develop abundant, efficient, and affordable systems
- **Crew Health & Safety**
  - Develop countermeasures and establish medical autonomy
- **Human & Robotic Operations**
  - Reduce time, distance and safety barriers; maximize science return
- **Space Systems**
  - Reduce cost and mass; greatly improve reliability, lifetime and operational robustness

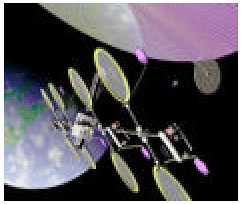


Nuclear Propulsion

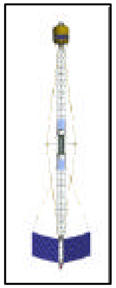


Invariant Manifolds

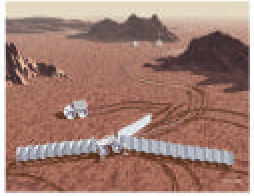
Entry, Descent & Landing



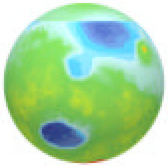
Space Solar Power



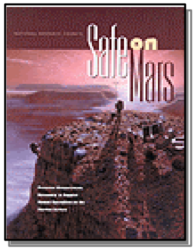
Artificial Gravity



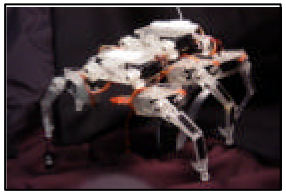
Brayton Engines



Mars Surface Neutron Model

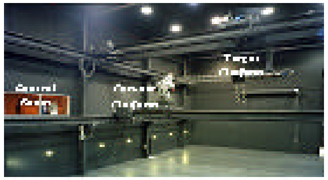


Precursor Requirements

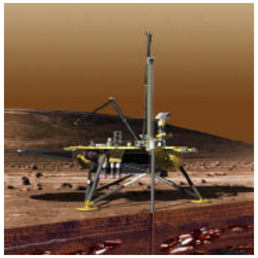


All-Terrain Mobility Robots

Telescope Assembly



Wireless Systems



Mars Drill Prototype

Overview –
Technology Requirements from Science Objectives

The primary objective in developing mission architectures is to define economical approaches to exploration. The science objectives define the potential destinations for human exploration. Mission analyses and development of design concepts serve to quantify the benefits and implications of mission approaches and technologies. The design concepts are used as existence proofs and are not presumed to be final designs. Mission concepts are studied with a view towards minimizing the infrastructure to support the range of potential destinations. The science-driven objectives include exploration of the moon, Mars, and asteroids. Objectives also include the construction and maintenance of advanced interferometers to be deployed at the Sun-Earth L_2 libration point. Common vehicle elements, habitats and other infrastructure are defined over the range of potential destinations to develop an efficient approach. By calculating the benefits of technologies employed through iterative mission analyses, technologies are identified which make considerable improvements in vehicle masses. Even provocative technologies are studied with the purpose of discovering what could be breakthroughs in designs or mission concepts. The primary objective for this process is to identify needed investments in enabling technologies.

Technology Requirements from Science Objectives

Potential Destinations from Science Objectives	Common Capabilities	Technology Building Blocks

Mission Analyses

System Design(s)

- Efficient In-Space P
- Aeroassist
- Low-cost Engines
- Cryo Fluid M
- Robust/Efficient P
- Lightweight S
- Radiation Research
- Zero/Low-g Research
- Regenerable Life S
- Advanced Lightweight Extra-Vehicular Activity Suits

"Breakthrough" Technologies (Examples)

- Wireless Power Transmission
- Regenerative A
- Revolutionary Earth-to-Orbit Rockets
- Innovative Mission Concepts

Overview –
Technology Investment Approach

A near-term, leveraged technology investment and development program is required to develop the incremental approach and enable the decision space and pathways for achieving further human and robotic exploration. The NEXT promotes an integrated, sustained technology investment program linked to specific capability goals that are traceable to major, NASA-wide science objectives. The NEXT strategy is science driven and technology enabled. Technology performance requirements are derived from architectural studies and technology trades necessary to execute the space exploration strategy.

NASA's space exploration activities are guided by the Space Act, Agency Strategic Plan, the Enterprise Strategic Plans, and direction included in the annual congressional appropriations. Largely based on the Space Act and the Agency Strategic Plan, NASA has articulated science pursuits for the Enterprises. NEXT ensures that science goals determined by the Enterprises remain the foundation of its activities to pursue the answers to fundamental science questions.

Based on this foundation, NEXT defines top-level requirements and applies systems engineering practices to NASA efforts. From the compiled science goals—and guided by top-level requirements — NEXT identifies architectural studies and analyses that would lead to potential missions meeting science goals. Analyses of the interrelated technology requirements inherent in the architectures and mission options leads to specific technology trade studies and then to technology road maps defining the technology developments necessary for the execution of the space exploration strategy. Gap analyses of the road maps against current capabilities and known technology development efforts result in identification of the highest priorities for technology development, generation of technology requirements and required system performance thresholds, recommendations for new initiatives, and requirements recommendations for extant NASA development programs.

As the NEXT efforts mature, the output of this process will provide a coherent "one NASA" picture of how to best invest available resources to produce the technologic foundation necessary for the efficient execution of NASA's mission – a comprehensive strategic investment plan for the future. Future revisions of the Agency and Enterprise Strategic Plans will use NEXT products – including technology requirements, priorities, and new initiatives – as inputs to guide the Agency's space exploration strategy.

Technology Investment Approach

Space Act & NASA Strategic Plan

Science : Questions, Pursuits, Activities

Requirements and Systems Engineering

Architectural Studies & Technology Trades

Technology Road Maps

Gap Analysis

Products:

Technology Requirements, Priorities, and New Initiatives

Overview –
NEXT Inter-Center Organization

NEXT is an interdisciplinary, cross-Enterprise, cross-Center team responsible for maintaining a multidisciplinary approach toward future exploration planning. Members include engineers, space scientists, earth scientists, astrobiologists, life scientists, astronauts, and physicians. Initially, the team consisted of 20 individuals from most of the NASA Centers including members from NASA Headquarters (HQ), Johnson Space Center (JSC), Marshall Space Flight Center (MSFC), Goddard Space Flight Center (GSFC), Ames Research Center (ARC), Langley Research Center (LaRC), and the Jet Propulsion Laboratory (JPL). The Associate Administrators for the Offices of Space Flight (OSF) and Space Science (OSS) served as the primary stakeholders in the process.

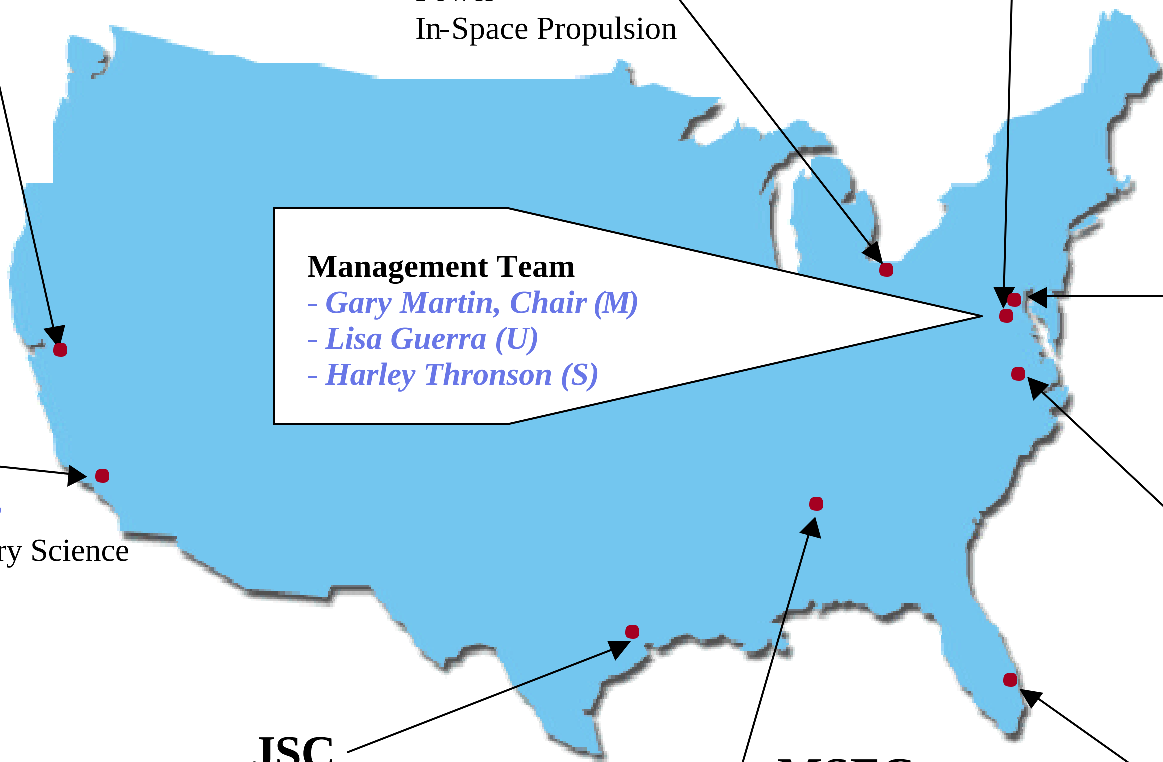
The Team membership includes experts in space sciences, propulsion technology, astrobiology, human biomedical sciences, general life sciences, programmatics, computer sciences, human space flight, materials sciences, microgravity and life sciences, and public outreach. The Chair has the authority to modify the team as needed to ensure adequate breadth and capabilities. Team members were added to provide expertise in information technology and systems analysis.

Membership has increased to approximately 70 full-time equivalents, composed of civil servants, contractors, and university personnel, to support the detailed studies and analyses. NEXT operates in a "virtual" manner where activities are conducted primarily through teleconference and electronic communications with periodic all-hands site meetings.

Functionally, formal interfaces have been established with NASA senior management to provide coordination among the Enterprises, and sub-teams have been formed to focus resources on programmatic priorities.

NEXT Inter-Center Organization

Sponsors:
Edwin Weiler/OSS
William Readdy/OSF
Mary Kicza/OBPR



ARC
Jan Aikins
Information Technology
Astrobiology

GRC
Robert Cataldo
Power
In-Space Propulsion

HQ
Marc Allen (S)
John Mankins (M)
Guy Fogleman (U)
Julie Pollitt (R)
Ed Torres (Y)
Strategic Missions
Strategic Architectures
Technology Road Maps

Management Team
- Gary Martin, Chair (M)
- Lisa Guerra (U)
- Harley Thronson (S)

GSFC
Rud Moe
Science
Telescope Servicing

JPL
Robert Easter
Space/Planetary Science
Robotics
Optics

LaRC
Melvin Ferebee
Systems Analysis and Engineering
Structures & Materials
Engineering Tools

JSC
Doug Cooke
Life Sciences
Human Support Technologies
Mission Analysis and Advanced Concepts

MSFC
Les Johnson
Space Transportation
(In-space; Earth-to-Orbit)

KSC
Chris Guidi
Launch System Operations and Range Technology

Overview –
NEXT Functional Structure

The NEXT organization is a collaborative activity, led by a Management Team composed of representatives from the Offices of Space Flight, Space Science, and Biological and Physical Research.

The role of each NEXT working group and team is to conduct analyses on their subject matter specialties and to provide inputs to the other working groups and teams. These working groups are essential for performing the detailed work needed to develop science scenarios, advanced concepts, and prioritize technology development.

The Systems Engineering Team (SET) provides the integration of all NEXT working group tasks and the development and control of requirements, goals, and milestones.

The Advanced Concepts Team (ACT) provides systems analysis to develop advanced concepts which achieve the science objectives in the most affordable, productive, and safe manner. Technologies and mission concepts are developed into system architectures. These architectures will be used to identify and prioritize key technologies and technical requirements necessary to achieve NEXT goals.

The Exploration Science Working Group (ESWG) ensures that science priorities determined by the Enterprises remain the foundation of NEXT goals.

The Technology for Human/Robotic Exploration and Development of Space (THREADS) Team develops technology programs that will enable the human/robotic exploration capabilities defined by the NEXT.

The Revolutionary Aerospace Technology Working Group (RATWG) seeks and identifies innovative concepts and technologies that can have a dramatic effect on future exploration missions.

The Human/Robotic Working Group (HRWG) analyzes and advocates effective partnerships between humans and robots in planetary and deep space exploration..

The Humans as a Subsystem Working Group (HSWG) carries out studies and identifies technologies and requirements that ensure architectures support a healthy and productive crew during and after operations.

The Transportation Working Group (TWG) analyzes and defines the space transportation technologies and requirements to achieve NEXT goals.

NEXT Functional Structure

Management Team

Center Leads
Effective utilization of Agency resources

Executive Officer
Resource tracking

Systems Engineering Team
Integrate all NEXT tasks; develop and control requirements and milestones; recommend new initiatives

Advanced Concepts Team
Develop advanced concepts to achieve the science objectives affordably, efficiently, and safely

Technology for Human/Robotic Exploration and Development of Space Team
Develop technology programs to enable human/robotic exploration capabilities defined by NEXT

Exploration Science Working Group
Ensure that Enterprise defined science priorities form the foundation for NEXT goals

Transportation Working Group
Analyze and define space transportation technologies and requirements

Human/Robotic Working Group
Analyze and advocate effective partnerships between humans and robots

Humans as a Subsystem Working Group
Identify technologies and requirements to ensure a healthy and productive crew during and after operations

Revolutionary Aerospace Technology Working Group
Search for innovative concepts and technologies

Overview –
How We Work – Evolution of an Artificial Gravity Vehicle

NEXT functions as a multi-disciplinary team that draws upon the expertise of subject matter experts within the Teams/Working Groups. The Advanced Concepts Team takes the lead in architecture study efforts and continually iterates concepts with members of the working groups. The state of the technology for the target concept is taken from the Technology for the Human/Robotic Exploration and Development of Space (THREADS) Team road maps. All of the factors are fed back into the architecture to yield new system concepts. Through this process, many diverse problems are addressed that show how the exploration hurdles may be overcome through strategic investments.

As an example of how NEXT functions, the hurdles of crew health and safety risk associated with long-duration microgravity exposure has led to consideration of a continuous 1-g artificial gravity vehicle for transportation to Mars. A desire to reduce trip times to minimize radiation exposure led to the choice of a nuclear electric propulsion system which is an excellent match for an artificial gravity vehicle.

The synergy between nuclear electric propulsion, nuclear power, and a rotating spacecraft, plus advances in advanced structures and inflatable technologies, led to a conceptual vehicle design which indicates that an artificial gravity vehicle is entirely feasible.

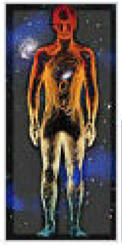
Abundant power is provided for the artificial gravity vehicle through two 15-megawatt direct boiling potassium reactors which are designed to have a four-year life at full power operation.

The structural design of this artificial gravity vehicle has been enabled through recent technology advances in structures for the sailing industry. Deployment and construction methods for these advanced trusses by human and robotic elements must be developed.

Follow-on studies will explore optimal vehicle configuration and operational concepts.

How We Work – Evolution of an Artificial Gravity Vehicle

Science Questions Addressed: How do Humans Adapt in Space? Is there life beyond Earth?



Hurdles - Crew Health & Safety

- *Radiation Concerns*
- *Long-Duration μ-Gravity Physiological Concerns*

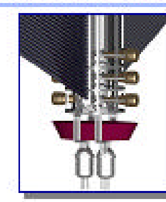
MITIGATION

- *Faster trip times*
- *Radiation shielding*
- *Artificial gravity*

Hurdles – Space Transportation

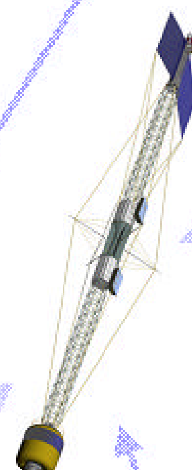
Hurdles - Power

Nuclear Electric Propulsion & Power



Architectures - Artificial Gravity Vehicle

- *1-G Continuous, 4 RPM*
- *Nuclear Electric Propulsion and Power*

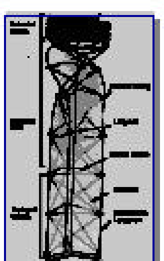


Technology Planning

- *Nuclear Systems - thrusters, reactors, power conversion*
- *Structures*
- *Radiation Shielding*
- *Human Support Systems*
- *Human/Robotic Agents*

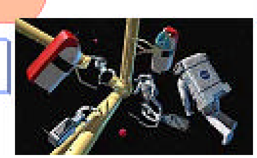
Hurdles – Space Systems

Advanced Structures



Hurdles - Human/Robotic Operations

- *In-Space Construction*



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FY02 Priorities

- Systems Engineering Team
  - Develop top level exploration requirements from NASA mission and vision, Enterprise strategic plans, and science goals
  - Integrate NEXT Working Group FY02 tasks and the development of FY03 tasks
  - Develop requirements for NEXT internal and external interfacing
- Advanced Concepts Team
  - Define a set of Design Reference Missions (both new and existing) which describe the supporting architectures to achieve various science mission goals
  - Derive human/robotic exploration requirements from Design Reference Mission analysis
  - Develop an artificial gravity vehicle concept to help mitigate crew health and safety concerns
  - Work with the science working group and human/robotic working group to help determine the optimal capability to construct large telescopes in space
- Technology for the Human/Robotic Exploration and Development of Space (THREADS) Team
  - Conduct the THREADS-Revolutionary Aerospace Technology Working Group (RATWG) Workshop to identify and assess innovative architectures, revolutionary concepts, and technology needs and opportunities
  - Perform Human Capital gap analysis
  - Initiate development of the TITAN model
  - Update the THREADS Strategic Research & Technology Road Maps

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FY02 Priorities (continued)

- Exploration Science Working Group
  - Develop advanced in-space construction and assembly techniques for the assembly and deployment of a large space telescope
- Transportation Working Group
  - Perform space transportation gap analysis to provide recommendations to augment existing Agency space transportation programs, new programs, and precursor missions for human/robotic exploration
  - Conduct a workshop to identify elements of in-space transportation infrastructure to be manufactured in space
  - Develop tools and methodologies to analyze exploration, spaceport, and maintenance operations to reduce cost and to increase safety and efficiency
  - Develop strategic research and technology road maps with the THREADS Team
- Humans as a Subsystem Working Group
  - Publish guidelines on human mission design
  - Continue evaluation of concepts to mitigate crew health and safety risks

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FY02 Priorities (continued)

- Human/Robotics Working Group
  - Benchmark space robotics state-of-the-art and identify technical challenges for future technology development
  - Partner with industry and academia to advance human/machine interaction
  - Conduct field tests and advance the state-of-the-art in robotic surface exploration and human/machine interaction
  - Develop and apply analytical tools for assessing the utility of various combinations of humans and robots to perform a given mission
- Revolutionary Aerospace Technology Working Group
  - Identify and present Top 10 list of revolutionary technologies that are paradigm changing for use by the Advanced Concepts Team
  - Track, scan, and filter the innovations that can leverage or be leveraged to provide unique accelerated capabilities to NASA missions as well as other collaborating agencies
  - Initiate joint high-risk, high pay-off collaborative projects with the Defense Advanced Research Projects Agency (DARPA), Naval Research Laboratory (NRL), and other agencies

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